Description

Method and radio communication system for providing a control channel

The invention relates to a method and a radio communication system for providing a control channel, in particular within a mobile radio system with broadband channels and TDD or FDD transmission mode.

In radio communication systems, messages (for example voice, image information or other data) are transmitted over a radio interface using electromagnetic waves. The term radio interface refers to a connection between a base station and subscriber stations, it being possible for the subscriber stations to be mobile stations or fixed radio stations. The irradiation of the electromagnetic waves is carried out here with carrier frequencies lying in the frequency band provided for the respective system. Frequencies in the frequency band of approximately 2000 MHz are provided for future radio communication systems, for example the UMTS (Universal Mobile Telecommunication System) or other 3rd generation systems.

Two modes are provided for the third generation mobile phone system, one mode designating an FDD mode (frequency division duplex), see ETSI STC SMG2 UMTS-L1, Tdoc SMG2 UMTS-L1 221/98, dated 25.8.1998 and the other mode designating a TDD mode (time division duplex), see DE 198 27 700. The modes of operation are applied in different frequency bands and both use time slots.

In ETSI STC SMG2 UMTS-L1, Tdoc SMG2 UMTS-L1 221/98, dated 25.8.1998, a synchronization method which uses synchronization sequences which are transmitted in each time slot is described in chapters 2.3.3.2.3 and 6.3 for the FDD mode. This thus makes it possible to synchronize the subscriber

stations with the start of the time slot. The order of the transmissions of a second synchronization sequence signals which code group (scrambling code) is being used by the base station. Furthermore, the frame start can also be derived therefrom.

A method for providing a control channel, according to which a channel is established in a predefined frequency band for transmitting the control information, is known from the GSM mobile radio system (global system for mobile communications). Only a limited amount of control information, which is sufficient in the GSM mobile radio system for signaling to the voice services, can be transmitted over this one channel.

The invention is based on the object of specifying a method and a radio communication system with which a greater degree of flexibility can be achieved in the provision of a control channel. This object is achieved by means of the method having the features of claim 1 and the radio communication system having the features of claim 14. Further developments can be found in the subclaims.

According to the invention, one or more channels which form the control channel are assigned to a base station in order to transmit control information. This makes it possible to vary the data rate of the control channel. At least one synchronization sequence is transmitted by the base station, the channel or channels of the control channel corresponding to the selection of one or more synchronization sequences and/or to the order of a plurality of synchronization sequences. A subscriber station receives the at least one synchronization sequence and determines the configuration of the control channel on the basis of the recognized synchronization sequence which designates the channel or channels and/or on the basis of the recognized order of a plurality of synchronization sequences.

In order to signal the configuration of the control channel, it is possible, for example, to use a large number of variants of a single synchronization sequence and/or the order of the transmission of different synchronization sequences. In this way, an indication of a scalable control channel is possible even in the synchronization phase and with little additional expenditure.

The control channel can be adapted to the individual requirements of the individual radio cells and also over time in accordance with the services offered. The flexibility of the provision of control information over the control channel is thus significantly greater.

The configuration of the control channel in the TDD mode is advantageously designated by the number, the time slots used within a frame structure and/or the spread codes used for the channels. In the FDD mode, this is a combination of scrambling code and code which designates the channel (channelization code). This information may be complete in itself or may relate to parameters which are previously known on a system-wide basis. In accordance with the instantaneous requirements of a radio cell, the capacity of the control channel is adapted in a way which can be traced by the subscriber stations, in that, for example, additional spread codes in an already assigned time slot and/or additional time slots with a spread code are assigned as channels within the control channel and the assignment is signaled using the synchronization sequences. When the required capacity is reduced, the assignment is cancelled, as a result of which the capacity is expanded with the channels which have become free for the transmission of user data.

A high coding gain is achieved if the coding of the configuration of the control channel by means of the selection

and/or the order of the synchronization sequences extends over a plurality of time slots or a plurality of frames. If, for example, 17 variants of the second synchronization sequence are used and the order of eight transmissions of the second synchronization sequence is evaluated, 17^8 possibilities are available. Only a small proportion of these have to be used.

The synchronization sequences are advantageously unmodulated orthogonal gold codes. It is therefore hardly necessary to modify the synchronization method of the FDD mode. The synchronization method is suitable in particular for radio communication systems in which the time slots are part of a TDD transmission arrangement with broadband channels. Here, a plurality of time slots can be used per frame for signaling the configuration of the control channel. However, it is also possible to use in FDD mode. For multimode subscriber stations it is possible to use parts of the detection device for both modes.

In order to use as few system resources as possible for "broadcast" purposes in TDD mode, the synchronization sequences are transmitted in time slots in which control information of the control channel is additionally transmitted. In this way, only a small number of time slots have to be continuously kept available in the downlink direction (from the base station to the subscriber station). The degree of freedom of the asymmetry of the two transmission directions is hardly restricted. In order to keep the interference on the other channels caused by the synchronization sequences low, said other channels are transmitted with lower power than the other transmissions of the base station, for example the control information. This disadvantage can be easily compensated by the coding gain.

As in the FDD mode described above, two synchronization sequences are advantageously

transmitted in one time slot. The first synchronization sequence is used to determine the reception time and the coarse synchronization. The order of the second synchronization sequences over a plurality of transmissions encodes the control channel and possible other information such as a time offset of the transmission within the time slot. According to one advantageous development of the invention, a time interval is predefined between the two synchronization sequences in one time slot. This provides the possibility of using a single, switchable filter for detecting both synchronization sequences. The second synchronization sequence can also be transmitted before the first so that the time interval is negative. Further information can be encoded with the time ratio of the first synchronization sequence to the second synchronization sequence. If two different filters are used, the two sequences can also be transmitted simultaneously. If there are two chronologically separated synchronization sequences, the disruptive interference is better distributed over time so that less burst-like interference occurs.

It is also advantageous to transmit further information by means of a selection of the synchronization sequences and/or their order. This permits more rapid readiness to operate of the subscriber stations. The further information relates to a frame synchronization and midambles and spread codes used by the base station in the TDD mode, or the code group (scrambling code) used by the base station in the FDD mode.

Exemplary embodiments of the invention are explained in more detail with reference to the appended drawings, in which:

Figure 1 shows a radio communication system,

Figure 2 shows a schematic representation of a TDD radio interface between the base station and subscriber stations,

Figure 3 shows an arrangement for transmitting synchronization sequences,

Figure 4 shows control channels which are configured in different ways, and

Figure 5 shows a flowchart representing the synchronization and the determination of the configuration of the control channel.

The mobile radio system illustrated in figure 1 as an example of a radio communication system is composed of a plurality of mobile switching centers MSC which are interconnected to one another and which form the access to a fixed network PSTN. Furthermore, these mobile switching centers MSC are connected to, in each case, at least one device RNC for controlling the base station BS and for distributing radio resources, i.e. a radio resource manager. Each of these devices RNC in turn permits connection to at least one base station BS. Such a base station BS can set up a connection to a subscriber station, for example mobile stations MS or other mobile and fixed terminals, over a radio interface. The subscriber stations MS contain synchronization means SYNC for synchronizing, and evaluation means AUS for detecting and evaluating the signals received by the base station BS. At least one radio cell is formed by each base station BS.

Figure 1 shows, by way of example, connections V1, V2, V3 for transmitting user information and signaling information between mobile stations MS and a base station BS, and a control channel BCCH as a point-to-multipoint connection. Control information oi which can be evaluated by all the subscriber stations MS and data relating to the services offered in the radio cell and relating to the configuration of the channels of the radio interface are contained in the control channel BCCH.

An operations and maintenance center OMC performs monitoring and maintenance functions for the mobile radio system or for part thereof. The functionality of this structure can be transferred to other radio communication systems in which the invention can be used, in particular for subscriber access networks with wireless subscriber connection.

The frame structure of a TDD (time division duplex) radio transmission can be seen in figure 2. According to a TDMA (time division multiple access) component, there is provision for a broadband frequency range, for example the bandwidth B = 5 MHz, to be split up into a plurality of time slots ts of the same duration, for example 16 time slots ts0 to ts15. A frequency band extends over a frequency range B. Some of the time slots are used in the downlink direction DL, and some of the time slots are used in the uplink direction UL. By way of example, an asymmetrical ratio of 3:1 in favor of the downlink direction DL is shown.

In this TDD transmission method, the frequency band for the uplink direction UL corresponds to the frequency band for the downlink direction DL. The same is repeated for further carrier frequencies. The variable assignment of the time slots ts for the uplink direction or downlink direction UL, DL enables various asymmetrical resource assignments to be performed.

Within the time slots ts, information on a plurality of connections is transmitted in radio blocks. The data d is spread on a connection-specific basis with a fine structure, a spread code c, so that at the receive end it is possible, for example, to separate n connections by means of this CDMA component (code division multiple access). The spreading of individual symbols of data d has the effect that Q chips of the duration T_{chip} are transmitted within the symbol duration T_{sym}. The Q chips form the connection-specific spread code c here.

One channel K1, K2, K3, K4 is designated within a frequency band B by a timeslot ts, a spread code c and thus implicitly a spread factor. The dimension of the time slot ts is not present in the FDD mode.

Within a broadband frequency range B, the successive time slots ts are divided up in a frame structure. 16 time slots ts are thus combined to form a frame fr.

The parameters used for the radio interface are advantageously:

chiprate:	4.096 Mcps
frame length:	10 ms
number of time slots:	16
length of a time slot:	625 µs
spread factor:	16
type of modulation:	QPSK
bandwidth:	5 MHz
frequency repetition value:	1

These parameters permit the best possible harmonization with an FDD mode (frequency division duplex) for the 3rd generation mobile phone system. Signaling to the control channel BCCH can be carried out using the synchronization sequences described below, not only in TDD mode but also in FDD mode.

In the downlink direction according to figure 3, two time slots ts0, ts8, for example, are used for synchronization. Thus, in one time slot ts8, in each case two synchronization sequences cp, cs are transmitted separated by a time interval tgap. The separation of the two synchronization sequences cp, cs has the advantage of reduced interference because the noise power of the two sequences is distributed better over time. The first synchronization sequence cp is the same in each time slot ts0, ts8. The second synchronization sequence cs

can be newly selected from time slot ts0 to time slot ts8.

The selection and order of the second synchronization sequence cs corresponds to a time offset toff with which the transmission of the first synchronization sequence cp is delayed with respect to the start of the time slot ts8. As a result of the reception and evaluation of the synchronization sequences cs, the receiving subscriber station MS can determine the time offset toff and take it into account in the synchronization.

Adjacent base stations BS are frame-synchronized in TDD mode. According to the invention, adjacent base stations BS are assigned a different time offset toff for the transmission of the synchronization sequences. For example, 32 different time offsets toff are used so that cell groupings (clusters) can be formed, and if the time offset toff changes for a base station BS it is not necessary to change the entire grouping.

As a result of the selection and order of the second synchronization sequences cs over, for example, 4 frames fr and two time slots ts0, ts8 per frame fr, when 17 different unmodulated orthogonal gold codes with 256 chip length are used, 17^8 different possibilities with which further information can be transmitted in addition to the time offset toff are obtained. As a result of the large number of possibilities, the coding gain is large so that the synchronization sequences cp, cs can be transmitted with little power.

The further information relates to the frame synchronization, midambles used by the base station, spread codes (midambles and spread codes being allocated independently of one another) and data relating to the configuration of a control channel

BCCH. When two time slots ts per frame fr are used for synchronization, the frame start after the synchronization is recognized in a time slot ts

is still imprecise with the factor two. The frame synchronization can consequently easily be brought about by means of a specific order of second synchronization sequences cs. Furthermore, the later detection of information of the control channel BCCH is speeded up if midambles, spread codes and data relating to the configuration are already transmitted during the synchronization.

In particular the possibility arises of introducing a scalable control channel BCCH which is indicated by the order of the synchronization sequences cs irrespective of the use of the time offset toff. According to figure 4, it is possible, for example, to transmit control information in one, two or four channels. As a result of the signaling with the synchronization sequences cp, cs, any desired channels K1, K2, K3, K4 designated by spread codes c and time slots ts, even above the number four can also be signals. In transmission methods without a TDMA component or without a CDMA component, the data relating to the time slots ts and the spread codes c becomes superfluous. Other parameters relating to the channels K1, K2, K3, K4 of the control channel BCCH may possibly have to be signaled depending on the transmission method selected.

In this way, the data rate of the control channel BCCH can be matched to the cell-specific requirements in accordance with the services offered there. Future modifications of the control channel BCCH are thus made possible. The parameters (number of channels, time slots and spread codes) of the control channel BCCH do not therefore need to be defined in advance on a system-wide basis but rather can be signaled during the synchronization.

In addition to the variants in figure 4, it is also possible to indicate additional channels with control information by means of the further information

from the synchronization. Thus, control information can also be transmitted temporarily in additional channels. The control channel

BCCH becomes parallel to other user data connections, but is transmitted with greater error protection coding, if appropriate.

The transmissions of the control channel BCCH and of the synchronization sequences cp, cs are preferably located in the same time slot ts, as a result of which only two time slots ts0, ts8 have to be continuously reserved for the downlink direction DL. The adjustability of the asymmetry is limited only to a small degree.

If the asymmetry ratios in the system are such that more than two time slots ts0, ts8 are used for the downlink direction DL, control information can also be transmitted in the remaining timeslots ts assigned to the downlink direction DL. It is then also possible to transmit the control information exclusively in time slots ts in which the synchronization sequences cp, cs are not transmitted. In this way, the interference on the user data connections is reduced further. The flexibility of the control channel BCCH provides additional advantages because, for example, distribution among a plurality of time slots brings about a greater degree of immunity of the transmission to interference.

The use of a multicode transmission in the control channel BCCH (a plurality of spread codes c per time slot ts) within a time slot ts permits the data rate of the control channel BCCH to be increased adaptively. A similar effect can also be achieved by reducing the spread factor, which is also indicated by the selection and order of the synchronization sequences cs. The selection of the time slots ts for transmitting the control information can be coordinated by a superordinate entity, for example a radio resource manager, RNC, for a plurality of base stations BS.

The assignment, performed in a control device, for example the radio resource manager RNC of a base station system,

of time slots ts0, ts8 for the synchronization of channels K1, K2, K3, K4 of the control channel and of different time offsets toff with respect to the start of the time slot ts0, ts8 for the transmission of the synchronization sequences cp, cs precedes the synchronization as the first step 1. In a second step 2, a plurality of base stations BS transmit the synchronization sequences cp, cs in the predefined order, which is specific for each base station BS and corresponds to the time offset toff.

A subscriber station MS receives the synchronization sequences cp, cs in a third step 3 and carries out a coarse synchronization by means of the first synchronization sequence cp. As a result of the evaluation of the second synchronization sequences cs in a fourth step 4, the synchronization of the time slot to the start of the time slot ts is possible, after which, by evaluating the further information, the frame synchronization is also carried out in a fifth step 5. The steps 3 to 5 are carried out by synchronization means SYNC which are assigned to the subscriber station and which constitute, for example, a signal processor and correlators formed by signal-matched filters.

In a sixth step 6, the configuration of the control channel BCCH is determined in the evaluation means AUS formed by a signal processor, using the further information, and the preparation of the reception of the control channel BCCH is initiated.